Project Title: Enhanced genetic selection of dairy sheep for the Southern US

Producer (Farmer or Rancher)
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I am a new farmer, having purchased a 90-acre farm in 2004 after a year of planning and visiting sheep dairy operations. I currently manage a flock of 40 purebred East Friesian and crossbred sheep with the help of a livestock guardian dog and student workers, using a rotational grazing strategy. Half of the 40 acres dedicated to pasture and hay has been fenced to sheep grade at this point, and planning is underway for an energy-efficient sheep dairy and cheese plant, to be ready for milking in 2010. My goal is to develop a breed of dairy sheep that will support a sustainable and profitable farmstead cheese operation in Virginia.

I currently work as an academic pediatrician and biomedical researcher. My laboratory research has focused on developing new animal models of human disease using selective breeding and genetic analysis, and I have 30 years of experience in small animal husbandry and pediatric practice. I am an experienced and enthusiastic teacher, and I have led collaborative research groups for major projects investigating genetic control of human autoimmune diseases, including juvenile diabetes, systemic lupus erythematosus, and inflammatory bowel disease.

Since the arrival of my foundation sheep flock in 2006, I have managed their nutrition in a pasture-based forage system with minimal grain supplementation. The ewes have lambed successfully on pasture, with no significant intervention, for the past two seasons. All are seronegative for OPP, CLA, and Brucella, and new breeding rams are confirmed Brucella-negative prior to mating. Lamb survival has been >97% (with only 1 of a group of quads lost to cold stress in 2007), and both lambs and adults have been generally resistant to parasitic disease: less than 20% of the lambs, and only 1 adult, have required treatment with anti-helminthics based on careful monitoring for anemia (using FAMACHA) or growth failure. With this baseline, and the experience of 2 years behind me, I am excited about moving this flock toward improved performance through genetic selection and using my organizational experience to develop a local network of farmers interested in sustainable small ruminant farming.

Project Duration: 2 years

Statement of Problem

The sustainability of traditional small farming operations is rapidly declining. Factors contributing to this decline include the following:

- diminishing/unreliable sources of labor
- rapidly increasing costs for fuel to support farm operations and transport of product
- rapidly increasing costs for inorganic fertilizer and non-renewable plant resources
- requirement for increasingly intensive, costly management of biological threats
- low market prices for commodities requiring off-farm processing or distribution.

Most sustainable small farms will need to be manageable by a single individual, operating either alone with occasional hired labor or with a partner employed full-time off the farm. From recent farm census data, it is also clear that the primary farmer will increasingly be female and may have little or no background in farming. In order to be profitable, small farming operations cannot rely on heavy mechanical input or support a large recurring investment in seed stock, fertilizer, or health management costs. They will also require a focus on farm-based “value-added” strategies and the development of local markets to minimize transport, distribution, and storage costs. In return for operating with these constraints, however, small farms should have advantages of improved flexibility in response to changes in environmental conditions and shifts in local consumer demand.

One farming opportunity that will meet these requirements is a dairy sheep operation producing aged ewe’s-milk cheeses. Given reasonable availability of feed generated off-farm or adequate pasture, an operation milking 50-60 ewes over a 5-month season should produce sustainable income for a single farmer-operator in the Southeast region with a limited requirement for extra labor, land, or expensive equipment. However, there are impediments to realizing this opportunity.

The dairy breeds currently available in the US, East Friesian (EF) and Lacaune, are handicapped by extremely limited genetic variability and poor health performance under conditions of high heat and humidity. The limited genetic variability, which may play a role in their high risk for developing pneumonia and serious worm infestations, limits the ability of breeders to optimize both general health and the components in milk (fat, protein) that are required for high-quality cheese production.

These breeds are also poorly suited to production of meat lambs for a supplemental income stream, require routine shearing for optimal performance in very warm, humid areas, and produce wool of low quality. At present, there are few sheep breeds of any sort that thrive and are highly productive in the southern US. Consequently, sheep production in this region has reached very low levels, and few in the farming community have the expertise in husbandry, breeding, and health maintenance required to manage sheep as a profitable enterprise.

Development of a dairy sheep breed that will thrive under low-input conditions in the Southern region will require a focused effort involving individuals with expertise in breeding for the selection of complex traits and in the husbandry of small ruminants, as well as a network of individuals capable of working together to expand and test the breeding stocks under development. This proposal addresses both issues.

Statement of Proposed Solution

The major goal of this project is to increase the “dairy character” in a genetically mixed sheep flock while selecting for traits of food efficiency, parasite resistance, and spontaneous shedding.

In 2006, I acquired a flock of eight pregnant ewes and three rams that had been developed on a Virginia farm as a nucleus for production of a “hairy-dairy” sheep breed. This project was originally funded by a SARE grant to Amy Hayner of Waverly, VA. The genetic inputs included 3 founder EF sheep from a single source (Old Chatham Sheepherding company, Old Chatham, NY), as well as 2 St. Croix sheep and 3 Katahdins from Virginia farms. The breeding nucleus I received had been selected over 4 years for spontaneous shedding and high lambing rates, with acceptable lamb growth in a pasture-based feeding regimen. At the time I acquired the sheep, the EF (dairy) contribution was 13-25%. This flock produced 5 ewe lambs in the 2006 season after arrival on my farm. The 5 ewe lambs and 2 of the ram lambs were retained as potential breeding stock.

In order to expand the distribution and mixture of the desirable traits for the 2007 lambing season, I bred the 13 ewes with 3 of the mixed rams, chosen for lineage distance and optimal parasite resistance. This breeding produced 18 ewe lambs and 10 ram lambs, from which 14 ewes and 2 additional rams were retained as potential breeding stock based on parasite resistance (no requirement for anti-helminthic treatment), good growth on pasture (a stringent criterion during the 2007 drought), and probability of carrying the "hair" (shedding) trait. Scoring of the lines represented in the flock by the summer of 2007 suggested that the traits of efficient weight gain/meat conformation and handling ease were associated with higher percentage of Katahdin genetics, while parasite resistance correlated with a higher percentage of St. Croix genetics.

To increase the "dairy character" in the flock, I purchased two new EF rams in the summer of 2007. For the 2008 lambing season, 9 of the existing ewes and ewe lambs showing high levels of parasite resistance, good growth, and shedding were mated with a ram from the foundation flock also exhibiting high levels of these traits. This group will serve as a reservoir of the desired "non-dairy" traits. A second group of 14 ewes was mated to one of the new EF rams to produce offspring capable of transmitting a higher percentage of EF genetics for further trait selection.

My long-term goal is to develop a dairy sheep breed, requiring low inputs for feed, labor, and health maintenance, that is capable of supporting profitable farmstead (small-scale) or artisanal (cooperative) ewe's-milk cheese-making in the Southern US. This proposal requests funds to support a systematic analysis of genetic variation in my foundation flock of crossbred sheep carrying 50-60% EF (dairy) genetics, to develop a composite tool for selection of genetically determined parasite-resistance, and to generate an expansion flock suitable for selection based on milk volume and quality.

Approach and Methods

A. Breeding

Breeding will begin annually in October for March lambing. Two "best" ram lambs will be retained from each breeding group to assure a reservoir of genetic diversity and adequate ram fertility during expansion breeding.

- 2008: Three groups of ewes, varying in genetic composition (Table 1), were bred to one EF ram. Based on their ages and the breeding efficiency of the foundation flock, I expect 28 lambs. Two ram lambs from each group will be retained based on weights at 30 days, normalized using a table of adjustment factors including litter size and age of dam (*Sheep Industry Development Handbook*). All ewe lambs will be retained for further breeding.

Table 1: Ewes mated to EF ram: October, 2007

Group	Number	% EF	% Katahdin	% St. Croix
1	5	24.7	49.7	25.6
2	4	23.4	40.6	35.9
3	5	19.5	66.1	14.5

- 2009: Groups 1-3 ewes and the female offspring from Group 1 will be bred to the second EF ram to generate additional expansion stock (from 2008 ewes) as well as a high-percentage EF stock (from Group 1 offspring). To stabilize expression of selectable traits, intercrossing will be initiated with ewes from group 3 bred to a Group 2 ram, and vice versa. Only ewe lambs will be retained. Expected output: 30 ewe lambs.

- 2010: A 2008 ram from Group 1 will be mated with 2008 and 2009 Group 2/3 ewes. A 2008 ram from Group 2 or 3 will be mated with all 2008/2009 ewe lambs from Group 1. Expected output: 120 lambs.

B. **Characterization of genetic diversity**

- Scrapie protein: Genetic testing at position 171 will be performed on all foundation ewes, the EF rams, and all rams reserved as breeders (N=26). This will allow selection for resistance to scrapie, if "R" alleles are present in the foundation flock.
- Genetic variation: To estimate the amount of genetic variability in the existing flock, I will use a genome-wide sampling procedure based on PCR amplification of variable length repeat elements ("microsatellites") from genomic DNA (0.5 oz whole blood; jugular sampling). The number of variants at 50 locations distributed throughout the genome will be used to predict the amount of improvement that can be expected using the current breeding stock.

C. Trait scoring

A numerical score summed from the following trait measures will be assigned to each lamb:

- Pasture lambing: Ram lambs will be considered as potential breeders if their dams delivered/bonded without intervention or confinement. Ewe lambs from unsuccessful dams will be scored –20.
- Milk production: Adjusted weights at 30 days will be used as a measure of maternal milk production.
- Parasite resistance: Adjusted weights and hematocrits at 90 and 120 days will be used as indirect measures of worm burden, along with the inverse of fecal egg counts (Virginia VDACS laboratory). Egg counts will be also performed on dams 2 weeks after delivery in 2009 and 2010. The percentile score for each trait will be averaged for each lamb.

Timetable

The research period will begin with lamb weights, fecal egg counts, and hematocrit testing of the 2008 lambs on July 1, 2008 (90 days of age). It will terminate with the 90-day measurements for lambs born in 2010. Genetic testing will be completed in year 1.

Expected outcome 1: Since the literature suggests that stable transmission of traits generally requires 2-3 generations, I expect that first 1-2 generations of crossbred sheep will require shearing and worming at least once per year. A fraction of the lambs born in 2010 should be clearly expressing high levels of the selecting traits.

Expected outcome 2: Total trait scores, calculated for all lambs from 2009-2010, will be ued to rank the lambs by gender. From these lambs, I will select the highest scoring 50 ewes (from 100-120) and 10 rams (from 50-60 in 2009). These animals will form the basis of a 5-part rotational breeding scheme that will continue selection for non-dairy traits and also begin selection based on milk volume and protein/fat components in the next phase of this project (2011).

Expected outcome 3: The map of genetic variation established by microsatellite screening of the foundation flock will be used as the basis for a project to "map" the genes that control traits related to health and milk characteristics in the next phase of this project. Similar mapping efforts are underway for managing breeding selection for meat and wool traits in sheep, as well as dairy traits in Spanish sheep breeds.

Outreach Plan (250 words)
Where and how will you tell others (producers, extension and/or researchers) about your results? What is your outreach plan? Outreach plans may include workshops, field days, fact sheets, articles, presentations at agriculture meetings and more. No more than 250 words (fewer is OK).

Outreach will be accomplished in 3 ways:

- A website will be developed to provide a searchable, public interface for this project. The descriptive text will carry carefully chosen keywords to attract those interested in dairy sheep, environmental concerns in this region, specific traits, sheep breeding, and the breeds incorporated in this study. Once data collection begins, the website will be linked to a relational database for storing and calculating cumulative data on breeding and trait measurements so that normative data on the traits and the developing breed will be publicly available.
- With support from Michael Lachance, Virginia Cooperative Extension, I will develop a focus group of local farmers interested in small ruminants. We have identified 25-30 such farming operations within a 50-mile radius of the Nelson County Extension office. For biosafety reasons, we will meet at this facility rather than on members' farms. This group will be designed to share expertise in small ruminant husbandry, provide education in breeding management and genetic selection of small ruminants, and develop business plans for local on-farm or cooperative value-added enterprises involving dairy goats and sheep. I envision attracting a core group of local farmers with a serious interest in identifying resources, including additional grant opportunities, for the development of a regional sheep dairy cooperative.
- Once the first stage of this project is completed, I will seek opportunities to present the results to regional farming organizations, such as the Virginia Association for Biological Farming's annual producer conference and field events.

Cooperators (250 words per cooperator)
Please list any major cooperators and who they work for—or if they are a farmer--who have agreed to participate in your project. Briefly explain the role, in the project, of each

cooperator. No more than 250 words per cooperator (fewer is OK). **Do not list more than six cooperators.**

Michael Lachance is employed by Virginia Cooperative Extension and is based in my county. He has been active with sustainable agriculture initiatives over the course of his sixteen-year career. He is a Board member of the Virginia Association for Biological Farming (VABF) and sits on the Virginia SARE professional development programs (SARE- PDP) committee. He has agreed to assist with the execution of the study, to use his mailing lists to convene other small ruminant producers for outreach, and to provide meeting space so that producers can meet and learn without the fear of disease transmission to anyone’s farm. He has indicated he will seek SARE PDP support to enable other Extension agents and agricultural professionals to benefit from this study’s techniques and findings.

Aaron Mackey, Ph.D., will provide computer support for an integrated database and webpage for this project. Dr. Mackey designed a similar database for management of breeding and genotyping data for my laboratory projects that has accommodated, to date, more than 50,000 mice from more than 40 genetically different strains. The database for this project will use a commercially available platform (Filemaker Pro, Filemaker, Inc.) which is readily modified for data analysis and export to spreadsheet and html/xml-compatible formats. The website will include descriptive information about the project, its funding, and its progress, as well as digital images of the developing breed and direct feed data collected for trait selection.

Student workers will be recruited through the award-winning agricultural education program at the Nelson County High School, allowing young people considering a career in livestock farming a “hands-on” experience with developing a breed improvement program.